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Efficiency Evaluation of Two Chemical Pesticides and a Biocide for Controlling *Eobania vermiculata* Snails Infesting Guava Orchards

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ABSTRACT

In recent years, guava cultivation has gained great commercial prominence due to the increasing international demand for its fresh and processed products. The guava trees are subject to affect by many pests, one of which is land snails. The land snail, *Eobania vermiculata*, is one of the most serious pests in Egypt's agricultural fields and recently reclaimed areas, causing significant damage to plants. Chemical control is considered the best defense against land snails. Therefore, in the present study, the efficiency of two chemical compounds; Agrinate® (methomyl) and Gastrotox® (metaldehyde) as well as a biocide Biogard® (*Bt*), at a recommended field rates for controlling the land snail *E. vermiculata* was tested under field conditions in guava orchard at Alexandria Governorate. The obtained results revealed that all tested compounds exerted significant reduction in the number of living snails on guava trees one day after treatment and until the end of the experiment compared to untreated tress. According to reduction percentages, the three tested compounds were found to be toxic to *E. vermiculata* with various degrees; 79.39, 69.12 and 86.57% for methomyl, *Bt* and metaldehyde after 21 days of experiment, respectively. Also the average initial kill (%) were 28.67, 16.39 and 41.66 and average residual effect (%) were 67.98, 59.55 and 78.81 for methomyl**,** *Bt* and metaldehyde, respectively. In the comparison among the tested compounds, metaldehyde ranked first and showed the highest effectiveness against *E. vermiculata* infecting Egyptian guava, followed by methomyl and *Bt*.

INTRODUCTION

Guava (*Psidium guajava*) is a significant commercial fruit harvest planted in tropical and sub-tropical regions worldwide (Gill, 2016). It is one of the most beloved fruits around the world, stands out for its mouthwatering taste, high levels of vitamins, nutrients and dietary fiber, as well as several health benefits (Diwan and Shukla, 2004). The export volume in Egypt reached 15 thousand tons annually, out of a total production volume of 400 thousand tons, from the total cultivated area, which is estimated at about 37 thousand acres, indicating that the average production per acre ranges between 9 to 30 tons depending on the age of the tree (Ahmed and Mohamed, 2021). Cultivation of guava is concentrated in Lower Egypt (coastal areas), especially in the governorates of Beheira, Alexandria, Damietta, Kafr El-Sheikh, and Qalyubia. In Egypt, guava plantations are attacked by several pests, including gastropods, and snails have become destructive animal pests of guava trees.

Gastropods, a diverse group of invertebrates belonging to Mollusca phylum with soft, un-segmented bodies, make a substantial contribution to global biodiversity (Diaz et al. 2017). Of all the mollusk classes, only the gastropods have managed to successfully invaded land (Sandeep et al. 2012). Terrestrial gastropods, for example, snails and slugs, are regarded as serious pests in humid and temperate habitats around the world (Speiser and Kistler, 2002). *Eobania vermiculata* (Gastropoda: Helicidae) represent one of the most harmful and abundant snails in Egypt (Eshra, 2013). They inflict immense economic damage to a variety of agricultural crops and plants and decrease their yield and marketing quality, resulting in financial losses (Iglesias et al. 2003). Since these animals have chewing mouth parts, they can bite into various parts of the plant (Barker, 2002), and they leave behind highly obvious boles in the plant they are feeding on. Snails transmit viruses, bacteria, and fungi *via* scratching plant parts during feeding, which has a direct and indirect effect on plants (Raut and Barker 2002).

Thus, the need for effective controls and development of control measures has become imperative to protect various crops and reduce the economic loss. There are several chemical, mechanical and biological strategies have been employed for controlling these pests to limit their impact below damaging level (Raut and Barker, 2002). However, chemical control through pesticide application remains the most efficient approach due to its efficiency and ease of usage, especially when applied over large areas (Geasa et al. 2013; Castle et al. 2017).

There are no many chemical compounds have been commercialized for controlling snails; molluscicides as well as other insecticides, including few carbamates have been used either as contact poisons or toxic baits (Radwan et al. 2008; Radwan and El-Wakil, 1991; Sakovich, 1996; Abdallah et al., 1998).

Metaldehyde, one of the most traditional used molluscicides, was introduced in the late 1930s and first practiced in gastropod baits in the early 1940s (Edwards et al., 2009). In 1996s, it was reported that metaldehyde was utilized on 55% of the crop areas where land snail pesticides were used a(Garthwaite and Thomas, 1996). Although it is often applied as compressed pellets, it can also be applied by mixing into an edible matrix that is then utilized to cover an inert granular core, or as a spray in emulsified form (Henderson and Triebskorn 2002). Metaldehyde induces irreversible severe destruction of the mucus cells necessary for land life gastropods, resulting to dehydration and eventual death (Triebskorn et al. 1998).

Methomyl is a carbamate insecticide developed in 1966 and considered moderately poisonous to terrestrial gastropods (El-Okda et al. 1989; El-Shahaat et al., 2009). Carbamates are known to behave as nerve poisons by inhibiting acetylcholinesterase (Young and Wilkins, 1989), in addition to lose muscular tone and become immobile in intoxicated snails (Godan, 1983).

Recently, biopesticide formulations containing microorganisms employed as promising non-traditional pesticides are becoming more intriguing due to their increasing development worldwide, environmental friendliness, convenience of application and availability (Kumar et al., 2013). Bacteria are considered one of the microbial agents utilized for a number of pesticides. Among various bacteria, *Bacillus thuringiensis* (*Bt*), the entomopathogenic bacteria, stands out the most renowned microbial derived pesticides globally against different medical and agricultural pests with evidence of molluscicidal effect (Kramarz et al., 2007). *B. thuringiensis* is a gram-negative, soil-saprophagous, endospore-forming bacteria and it can generate toxic chemicals for many pests (Bravo et al., 2011).

In this study, a field experiment in a guava orchard was designed to investigate the efficacy of three commercially available compounds; namely Agrinate® (methomyl, insecticide), Biogard® (*B. thuringiensis*, biocide) and Gastrotox® (metaldehyde, molluscicide) against the most prevalent land snail species, E. vermiculata, in Alexandria Governorate, Egypt. Additionally, this study aimed to compare the molluscicidal activity of these commonly used compounds.

MATERIALS AND METHODS

Tested snails:

The adult land snail Eobania vermiculata, which infests guava (Psidium guajava) was investigated in the present field study.

Tested pesticides:

The commercial-based pesticides; Agrinate® 24% SL (methomyl) as a carbamate insecticide attained from Vapco\Veterinery & Agricultural Products Manufacturing. Co.; Biogard® 6.5% WP (B. thuringiensis) as a biocide obtained from Bio Tech for Biocides & Fertilizers; and Gastrotox® 5% GR (metaldehyde) as a tetroxocane molluscicide obtained from Central Agricultural Pesticides Laboratory (CAPL), Cairo, Egypt.

Field examination:

The efficacy of two chemical compounds; methomyl**,** metaldehyde; and a biocide, *Bt* was evaluated under field conditions against a serious terrestrial snail, *E. vermiculata* in an infested guava trees at Alexandria Governorate, Egypt, during May 2023. An area about one Fadden was chosen for the experiment. The orchard was irrigated 4 days before the treatment. The trial comprised of four treatments including the control, in a randomized complete block design (RCBD) with four replicates (3 trees each) per treatment. A distance of 20 m was separated between each treatment.

The tested compounds were evaluated with a recommended rate as follows: methomyl (1 L/Fed), *Bt* (500 g/Fed) and metaldehyde (2 Kg/Fed). Methomyl and *Bt* were sprayed using a knapsack sprayer (CP3) on the tree trunk and on the soil in 1 m^2 around the tree trunk by approximately 0.5 L containing 6.7 cm^3 methomyl and 3.3 g *Bt* for each tree. Metaldehyde granules were spread on plastic sheets (25 x 25 cm) around the trunk of each tree (13.3 g for each). The pesticides application was were renewed every 7 days. No treatment was applied for the control trees. Number of alive snails was counted on 1 m around the tree trunk and on the soil in 1m² adjacent to treatment area before and then after 1, 3, 7, 14 and 21 days of experiment (Ismail and Shetaia, 2009). The percent reduction in snail population density was estimated according to the formula given by Henderson and Tilton (1955) as follows:

% Reduction in snail's number = $100\ [1-(Cb \times Ta / Ca \times Tb)]$

where:

Cb= No. of alive snails in control before application;

Ca = No. of alive snails in control after application;

Tb= No. of alive snails in treatment before application;

Ta= No. of alive snails in treatment after application.

Statistical analysis

The data were analyzed by ANOVA, at a significance level of $p \leq 0.05$ using SPSS statistical software (IBM SPSS Inc., ver. 21).

RESULTS

Data in Table 1 indicated that the highest number of living snails was recorded in the control. The methomyl**,** *Bt* and metaldehyde treatments had significantly lower numbers of alive *E. vermiculata* snails from the 1st to the 21st days of experiment compared with the control. The results also revealed that the numbers of snails in the metaldehyde treatment were found to differ significantly than those in methomyl or *Bt* treatments at different time intervals. Whereas, no significant difference was observed between methomyl and *Bt* treatments at different time intervals of experiment. The total mean numbers of snail treated with methomyl**,** *Bt* and metaldehyde was 211.6, 222.6 and 132, respectively, compared with the control (446.8).

As shown in Table (2), the reduction percentages of *E. vermiculata* population treated with methomyl**,** *Bt* and metaldehyde gradually increased with increasing the time till 21 days of experiment. The results revealed that methomyl gave 19.92, 37.42, 55.14, 69.42 and 79.39 % reduction in snail numbers after 1, 3, 7, 14 and 21 days of experiment, respectively. *Bt* caused a moderately reduction with a percent of 10.57, 22.22, 50.62, 58.91 and 69.12 after 1, 3, 7, 14 and 21 days of experiment, respectively. The reduction percentages for metaldehyde were 25.28, 58.04, 70.31, 79.54 and 86.57 after 1, 3, 7, 14 and 21 days of experiment, respectively. Data also showed that average initial kill (%) after 3 days were 28.67, 16.39 and 41.66 and average residual effect (%) after 21 days were 67.98, 59.55 and 78.81 for methomyl**,** *Bt* and metaldehyde, respectively.

From the aforementioned results, it is apparent that metaldehyde was more toxic to the snail than methomyl and *Bt*, since it induced the highest % reduction, while *Bt* was the least one during the experimental period. Generally, the efficacy of the tested pesticides on the snails using the reduction percentage as an index can be arranged in descending order as: metaldehyde > methomyl > *Bt*.

DISCUSSION

Destructive pest species are one of the greatest concerns to biodiversity in agricultural crop. Once these damaging species have established themselves, it is very difficult to control their growth, population increase, spread, and damage to crops or economic losses. In recent years, there is an urgent need for solutions to control the increasing populations of the terrestrial snail in the Egyptian fields. Therefore, field experiments had been conducted to study the effectiveness of some chemical compounds on land snails infesting major crops in Egypt.

When discussing the present findings with other researches, it is deserved to indicate here that the toxicity of compounds may differ due to climatic conditions, natural conditions (humidity, temperature, and light), the application method, etc.

In the present study, the three tested commercial compounds (methomyl, *Bt* and metaldehyde) showed molluscicidal potential against *E. vermiculata* infesting guava trees and the highest toxic compound was metaldehyde after 21 days of experiment. Such results are in a harmony with those of Mortada et al. (2005) and Ismail and Shetaia (2009) who notified that metaldehyde was more efficient than methomyl in the control of land snail *Monacha cartusiana*.

The current data are close to Abdel-Kader et al. (2016) who tested the toxic effect of methomyl, metaldehyde and Bt in the field employing two different techniques (baits and spray) at recommended field rates on *M. cartusiana* in two fields cultivated with Egyptian clover and lettuce intercropping on cabbage. Results revealed that methomyl and metaldehyde showed the greatest efficiency in reducing snails number than *Bt* throughout the trial period (21 day).

The obtained result of methomyl are consistent with those obtained by several authors, who applied this pesticide against terrestrial gastropod pests; Rabelo et al. (2022) reported that during the field experiment, methomyl treatment reduced the populations of *Bulimulus bonariensis* snail in row crops more than the control. The field application of methomyl using a sprayer on lettuce plants gave 74% reduction in *M. cartusiana* population (Ahmed et al., 2023) and its application on citrus nursery trees achieved 80.5% reduction in *E. vermiculata* population (Mobarak et al., 2022). Additionally, Ismail et al., (2022) tested the efficacy of methomyl compound as virulent baits at four concentrations (0.5, 1.0, 2.0 and 3.0 %), with four different treatments (fresh baits and baits treat after one, three, and seven days) on orchard trees and ornamental plants under field conditions. They revealed that methomyl baits were effective in the reduction of *M. cartusiana*, *Succinea putris* (L.) and *E. vermiculata* populations when it applied as fresh baits, and baits treat after one, and three days, although its effect was diminished when it applied as baits treat after a week. In the field trial carried out by Khidr (2019) in citrus orchards using methomyl, it was proved that the tested compound achieved a population reduction of *E. vermiculata* by 64.48 % and *M. obstructa* by 91.31%. Moreover, Shahawy (2019) revealed that Agrinate (methomyl 24 % W.P) was toxic to *E vermiculata* snails under field conditions, since it achieved the reduction percentage of snail population by 69 %.

Table 1: Field performance of Agrinate®, Biogard® and Gastrotox® against the land snail, *Eobania vermiculata* on guava trees

Treatments	No. of living snails before treatment ± SE	No. of living snails after treatment ± SE					
		1 day	3 days	7 days	14 days	21 days	Mean
Control	391 ± 2.5	394 ± 1.6	382 ± 3.6	425 ± 3.1	500 ± 4.2	533 ± 2.7	446.8
Agrinate®	404 ± 2.1	326 ± 2.6*	247 ± 1.9*	197 ± 0.7*	158 ± 0.6*	130 ± 1.2*	211.6
Biogard®	354 ± 1.9	319 ± 1.5*	269 ± 1.9*	190 ± 2.5*	186 ± 0.6*	149 ± 1.9*	222.6
Gastrotox®	344 ± 3.1	259 ± 2.9*	141 ± 1.1*	111 ± 1.3*	90 ± 1.1*	63 ± 0.4*	132
$LSD_{0.05}$		16.40	15.76	14.56	15.01	12.82	

Significant differences from the respective control are indicted as * ($P \leq 0.05$).

Table 2: Reduction percent of Agrinate®, Biogard® and Gastrotox® against the land snail, *Eobania vermiculata* on guava trees

Treatments	Reduction percent (%)							
	1 day	3 days	Initial Kill %	7 days	14 days	21 days	Residual effect %	Mean
Agrinate®	19.92	37.42	28.67	55.14	69.42	79.39	67.98	52.26
Biogard®	10.57	22.22	16.39	50.62	58.91	69.12	59.55	42.31
Gastrotox®	25.28	58.04	41.66	70.31	79.54	86.57	78.81	64.22

Pallavi et al. (2018) noted that methomyl 40 SP poison bait recorded a high percent mortality against *Achatina fulica* on mulberry over one week of treatment. Hendawy et al. (2015) manifested that application of methomyl against *M. cantiana* and *M. cartusiana* in lettuce and cabbage plantations has been shown to be efficient in reducing the population of snails. Furthermore, Ismail et al. (2014) estimated the two application methods, spray and poisonous baits of methomyl against *M. cartusiana* and they indicated that the tested compound was practicable to reduce numbers of snails in Egyptian clover fields. After a 15-day field experiment with methomyl at Sharkia Governorate, the reduction percentages of E. vermiculata were obvious and reached 78.32 % (Hegab et al. 2013).

Regarding the value of metaledyde, the observed results also corroborated the results previously mentioned by other investigators; Limunga et al. (2020) found that throughout the 12-week experiment conducted in Cameroon, banana trees treated with Limace® (metaledyde 5 % GR) had lower mean number of alive snails on the corms and pseudostems compared with untreated trees. In addition, applying bait pellets containing either 15 g/kg or 40 g/kg of metaldehyde on the soil's surface, or as baitchain wrapped around the tree bases, or using in combination caused remarked mortality of *C. aspersum* snail in apple orchard (Pieterse et al. 2020). Moreover, Ismail et al. (2015) tested metaldehyde at three application techniques (hand sowing, under plant in stacks, and piles on plastic pieces) for M. *cartusiana* controlling in potato fields, and they found that the general means for the three techniques were 41.23, 30.04, and 32.94 %, respectively. Also, Mortada et al. (2005) reported that Molotov 3%, Gastrotox 5 % and Neomyl 90 % exhibited high mean reduction percentages against *M. cartusiana* infesting orange orchard after 21 days of treatment.

Concerning the efficacy *B. thuringienis,* Geasa et al. (2013) showed that after 28 days' residue effect, the biocides (Biogard, Protecto, Delfin and Agreen) decreased population density of M. cartusiana and Succinea oblonga snails by comparable low values of 50 to 55 %. Moreover, the average of population reduction percentage of *T. pisana* and *H. vestalis* infesting mandarin trees orchard exposed to the biocide Xentari (*Bt*) was 31.9 % and 32.02 % (Abdel-Rahman and Al Akra, 2012). In addition, Shetaia et al. (2013) illustrated that methomyl (Agrinate 24 % S.L) caused high effect against *M. cartusiana* under field conditions where mean reduction percent reached 77.17% while *Bt* (Zentari) gave 6.2 %. Mortada et al. (2012) evaluated the effectiveness of Biogard (as *Bt* formultion) and Gastrotox, Metarol and Molotov (as metaldehyde formultions) each as poison bait against *Monacha* sp snails infesting pea fields. The results showed that population density reduction after 3 days (Initial Kill) and residue effect after 21 days were 6.10% and 28.03 % for Biogard; 76.48 and 95.65 % for Gastrotox; 69.20 and 93.93% for Metarol and 64.33 and 95.78 % for Molotov, respectively. Genena and Mostafa (2010) observed that *B. thurinigensis* K64, and methomyl showed molluscicidal activity against *M. cantiana* with 23.0 and 100.0 % mortality, respectively, after four weeks of treatment.

CONCLUSION

Snails cause serious horticultural harm, which pose a significant threat to guava production. In the present investigation, the tested commercial pesticides; Agrinate® (methomyl), Biogard® (*Bt*) and Gastrotox® (metaldehyde) showed molluscicidal action against *E. vermiculata* infesting guava orchards in Alexandria Governorate. It is undeniably that metaldehyde was the most efficient compound followed by methomyl, however, *Bt* was the least efficient one. Generally, these findings reflect the efficacy of methomyl, *Bt*, and metaldehyde in controlling *E. vermiculata* under field conditions based on the Egyptian recommendations.

REFERENCES

Abd El Rahman, A.H.E. and Al Akra T.M.M. (**2012**). Integrated control using different methods against two land snail species *Theba pisana* (Müller) and *Helicella vestalis* (Pfeiffer) infesting *Citrus nobilis* trees at Sharkia Governorate. J. Plant Prot. and Path., Mansoura Univ., **3(6)**: 571-581.

Abdallah, E.A.M., El-Wakil, H.B., Kassem, F.A., El-Agamy, E.I. and Abo-Baker, Y. (**1998**). Impact of aldicarb and metaldehyde exposure on different molluscan enzyme activities and stress protein response. 7th Conf. Agric. Dev. Res. Ain Shams Univ. Cairo, Dec. Ann. Agric. Sci. **3**: 1103-1117.

Abdel-Kader, S.M., Hegab, A.M.I. and Mourad, A.A. (**2016**). Evaluating the efficiency of some different chemical compounds against *Monacha cartusiana* under field conditions at Sharkia Governorate. J. Plant Prot. and Path., Mansoura Univ., **7**(**9**): 605–608.

Ahmed F.A.A. and Mohamed S.S.Y. (**2021**). The economic impacts of some technical agricultural treatments for guava production in EL-Beheira Governorate. Alex. Sci. Exch. J., **42(2)**: 1039-1057.

Ahmed, H.Y, Al-Quraishy, S., Hassan, A.O., Abdel-Baki, A.S. and Abdel-Tawab, H. **(2023).** Biocontrol potential of *Trichoderma harzianum* against the Land Snail *Monacha cartusiana*: Lab and Field Trails. Int. J. Agric. Biol., **30(2)**: 79-89.

Barker, G.M. (**2002**). Mollusks as Crop Pests. CABI Publishing, Wallingford, Oxon, UK, p. 576.

Bravo, A., Likitvivatanavong, S., Gill, S.S. and Soberón, M. (**2011**). *Bacillus thuringiensis*: a story of a successful bioinsecticide. Insect Biochem. Mol. Biol., **41**: 423-431.

Castle, G.D., Mills, G.A., Gravell, A., Jones, L., Townsend, I., Cameron, D.G. and Fones, G.R. (**2017**). Review of the molluscicide metaldehyde in the environment. Environ. Sci. Water Res., **3**: 3415–3428.

Diaz, A.C., Martin, S, Mariani, R, and Varela, G.L. (**2017**). First record of *Cecilioides acicula* (Müller, 1774) (Mollusca: Ferussaciidae), from Buenos Aires province Argentina. Check List, **13**(**2**): 2096.

Diwan, A. and Shukla, S.S. (**2004**). Effects of treatments on reducing sugar and titrabale acidity of low-alcoholic beverage prepared from guava (*Psidium guajava*). J Food Sci Tech MYS, **41**(**2**): 210-213.

Edwards, C.A., Arancon, N.Q., Vasko-Bennett, M., Little, B. and Askar, A. (**2009**). The relative toxicity of metaldehyde and iron phosphate-based molluscicides to earthworms. Crop Protection, **28**: 289–294.

El-Okda, M. M. K., Emara, M. M. and Selim, M.A. (**1989**). The response of the harmful and useful terrestrial mollusca towards several toxicants. Efficacy of six toxicants under laboratory conditions. Alex. Sci. Exch., **10**(**3**): 375-385.

El-Shahaat, M.S, Aly, N.A., Eshra E.H., Mesbah, H.A. and Ghoneim E.I. (**2009**). Toxicity of certain copper fungicides and other pesticides to terrestrial snails. J. Agric. Sci. Mansoura Univ., **34**(**5**): 5501-5507.

Eshra, E.H. (**2013**). Survey and distribution of terrestrial snails in fruit orchards and ornamental plants at Alexandria and El-Beheira Governorates, Egypt. Alex. Sci. Exch. J., **34**: 242-248.

Garthwaite D.G. and Thomas M.R. **(1996)**. The usage of molluscicides in agriculture and horticulture in Great Britain over the last 30 years. In: Henderson I.F., editor. Slug and Snail Pests in Agriculture. Symposium Proceedings 66. British Crop Protection Council; Farnham, UK, pp. 39-46.

Geasa, N.S., Heiba F.N., Mortada M.M. and Mosbah I.S. (**2013**). Molluscicidial activity of certain biological insecticides against land snails *Monacha cartusiana* and *Succinea oblonga* in laboratory and field conditions. Egy. J. Zool., **60**: 179-188.

Genena, M.A.M. and Mostafa, F.A.M. (**2010**). Biological control of the clover land snail, *Monacha cantiana* (Montagu) using the Rhabditid Nematode, *Phasmarhabditis Hermaphrodita* (Schneider) under mini-plot field conditions. Egypt J. Agronematol., **9**(**2**): 149-156.

Gill, K.S. (**2016**). Guavas, in Encyclopedia of Food and Health, Pages 270-277.

Godan, D. (**1983**). Pest Slug and Snails, Biology and Control. Federal Biological Res. Center of Agric. and Forest. Knigin Luisestrable, 19 D-400, Berlin, 345 PP.

Hegab, A.M.I., Arafa, A.A.I. and Hilmy, A.E. (**2013**). Efficacy of methomyl and copper sulphate against *Eobania vermiculata* (Müller) and *Helicella vestalis* (Preiffer) snail under laboratory and field conditions. Annals of Agric. Sci., Moshtohor, **51**(**3**): 271–275.

Hendawy AS, SK El-Fakharany, and MA Samy (**2015**). Laboratory and field evaluation of molluscicide activity of native biological isolates compared to an insecticide against the land snails, *Monacha* spp. Egypt J. Biol. Pest Cont., **25**: 675–678.

Henderson, G.F. and Tilton, E.W. (**1955**). Test with acaricides against the brown wheat mite. J. Econ. Entomol., **48**: 157–161.

Henderson, I.F. and Triebskorn, R. (**2002**). Chemical control in terrestrial gastropods. In: Molluscs as Crop Pests (GM Barker ed). CAB International, London. pp 1-31.

Iglesias, J., Castillejo, J. and Castro, R. (**2003**). The effects of repeated applications of the molluscicide metaldehyde and the biocontrol nematode *Phasmarhabditis hermaphrodita* on molluscs, earthworms, nematodes, acarids and collembolans: A two-year study in north-west Spain. Pest Manage Sci., **59**: 1217–1224.

Ismail, G.H., Abou-Hashem, A.A.M. and Khider, F.K. (**2022**). Effect of methomyl on certain land snails under field conditions. Egypt J. Plant Prot. Res. Inst., **5**(**1**): 110–115.

Ismail, Sh.A.A. and Shetaia S.Z.S. (**2009**). Preliminary studies on *Monacha cartusiana* snail infesting cotton seedlings at Sharkia Governorate. Zagazig J. Agric. Res., **36**(**4**): 803- 814.

Ismail, Sh.A., Rady G.H., Abdel Gawad A.A. and Lokma M.H. (**2015**). Control studies on the glassy clover snail, *Monacha cartusiana* under laboratory and field conditions. Egypt. J. Agric. Res., **93**(**2**): 399-406.

Ismail, Sh.A.A., Shetaia S.Z.S.; Arafa A.A.I. and Khatta M.M. (**2014**). Field trials and the bait attractive distances and evaluation the efficacy of Methomyl using different control application methods against the gastropod pest *Monacha cartusiana* (Müller) infesting clover fields. J. Plant Port. And Path., Mansoura Univ., **5**(**6**): 697-703.

Khidr E.K. (**2019**). Efficiency of acetic acid and methomyl on terrestrial snails *Eobania vermiculata* (Müller) and *Monacha obstructa* (Ferossac) under laboratory and field *conditions. Azhar Bull. Sci*., **30**(**1**): 1-7.

Kramarz, P.E., De-Vaufleury, D. and Carey, M. (**2007**). Studying the effect of exposure of the snail *Helix aspersa* to the purified *Bt* toxin, Cry1Ab. Appl. Soil Ecol., **37**(**1**): 169-172.

Kumar, K., Yashaswini, K.S. and Earanna, N. (**2013**). Molecular characterization of Lepidopteran specific *Bacillus thuringiensis* strains isolated from Hilly Zone Soils of Karnataka, India. Afr. J. Biotechnol., **12**(**20**), 2924-2931.

Limunga, T.C.B., Monono, E.Y., Mathias, A.M. and Okolle, N.J. (2020). Comparing the molluscicidal action of metaldehyde, oxamyl, potassium nitrate and a botanical insecticide for managing *Limacolaria* spp infesting banana plantations in Cameroon. Int. J. Sustain. Agric. Res., **7**(**3**): 143-153.

Mobarak, S.A., Kandil, R.A. and El-Abd, N.M. (**2022**). Response of land snails to diclofenac-potassium under laboratory and field conditions. Egypt. J. Plant Prot. Res. Inst., **5**(**4**): 310 –317.

Mortada, M.M., Mourad, A.A.M., Abo-Hashem, A.M. and Keshta, T.M.S. (**2012**). Land snails attacking pea fields: II- Efficiency of certain biocides and molluscicides against *Monacha* sp. land snails at Dakahlia Governorate. J. Plant Prot. and Path., Mansoura Univ., **3**(**7**): 717-723.

Mortada, M.M., Soliman, A.M. and Khidr, F.K. (**2005**). Molluscicidial activity of certain compounds against *Monacha cartusiana* land snails under laboratory and field conditions. J. Agric. Sci. Mansoura Univ., **30**(**12**): 8147-8151.

Pallavi, H.S., Basavaraju, B.S., Umashankar, N., Shivashankar, T. and Rajegowda (**2018**). Evaluation of eco-friendly and chemical pesticides, and attractant solutions against giant African snail, *Achatina fulica* Bowdich on mulberry. J. Pharmacogn. Phytochem., **7**(**3**): 666-671.

Pieterse, A., Malan, A.P. and Ross, J.L. (**2020**). Efficacy of a novel metaldehyde application method to control the brown garden snail, *Cornu aspersum* (Helicidae), in South Africa. Insects, **11**, 437.

Rabelo, M.M., Dimase, M. and Paula-Moraes, S.V. (**2022**). Ecology and management of the invasive land snail *Bulimulus bonariensis* (Rafinesque, 1833) (Stylommatophora: Bulimulidae) in row crops. Front. Insect Sci., 2. https://doi.org/10.3389/finsc.2022.1056545

Radwan, M.A. and El-Wakil, H.B. (**1991**) Impact of certain carbamate and synthetic pyrethroids on the non-target terrestrial snails *Eobania vermiculata.* Alex. Sci. Exch*.*, **12**(**2**): 305-316.

Radwan, M.A., Essawy, A.E., Abdelmeguied, N.E., Hamed, S.S., and Ahmed, A.E. (**2008**). Biochemical and histochemical studies on the digestive gland of *Eobania vermiculata* snails treated with carbamate pesticides. Pesticide Biochem. Physiol., **90**: 154–167

Raut S.K. and Barker G.M. (**2002**). *Achatina fulica* Bowdich and other Achatinidae as pests in tropical agriculture. In: Molluscs as Crop Pests, pp: 55–114. Barker GM (Ed.). CABI Publishing, Wallingford, UK.

Sakovich, N.J. (**1996**). An integrated pest management (IPM) approach to the control of the brown garden snail, *Helix aspersa* in California citrus orchards. Slug & Snail Pests in Agriculture. BCPC Symposium No. 66, University of Kent, Canterburg, UR, 283-287.

Sandeep, S., Ravikanth, G. and Aravind, N.A. **(2012)**. Land snails (Mollusca: Gastropods) of India: status, threats and conservation strategies. J. Threat. Taxa **4(11)**: 3029- 3037.

Shahawy W.A. (**2019**). Field trials on land gastropods infesting some ornamental plants at Kafr El-Sheikh Governorate. J. Plant Prot. and Path., Mansoura Univ., **10**(1): 7–11.

Shetaia, S.Z.S., Arafa A.A.I. and Abd-El-Atty S.F. (**2013**). Efficacy of certain compounds against the glassy clover snail, *Monacha cartusiana* (Müller) at Sharkia Governorate. J. Plant Prot. and Path., Mansoura Univ., **4(1)**: 67-73.

Speiser, B. and Kistler, C. (**2002**). Field tests with a molluscicide containing iron phosphate. Crop Prot., **2**1: 389-94.

Triebskorn, R., Christensen, K. and Heim, I. (**1998**). Effect of orally and dermally applied metaldehyde on mucus cells of slugs (*Deroceras reticulatum*) depending on temperature and duration of exposure. J. Moll. Stud., **64**: 467-487.

Young, A.G. and Wilkins, R.M. (**1989**). A new technique for accessing the contact toxicity of molluscicide to slugs. J. Moll. Stud., **53**: 533-536.

الملخص العربي

تقييم كفاءة مبيدين كيميائيين ومبيد حيوي في مكافحة قوقع يوبانيا فيرميكولاتا الذى يصيب بساتين الجوافة

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في السنوات الأخيرة، اكتسبت زراعة الجوافة أهمية تجارية كبيرة بسبب الطلب العالمي المتزايد على منتجاتها الطازجة والمصنعة. تتعرض أشجار الجوافة للتأثر بالعديد من الآفات، مثل القواقع البرية. يعتبر القوقع البنى (يوبانيا فيرميكولاتا) واحد من أخطر الآفات التي تصيب الحقول الزراعية في مصر والمناطق المستصلحة حديثًا، مما يسبب أضرارًا كبيرة للنباتات. تعتبر المكافحة الكيميائية أفضل وسيلة دفاع ضد القواقع الأرضية. لذلك في الدراسة الحالية، تم قياس كفاءة مركبين كيميائيين؛ وهى؛ أجرنيت (ميثوميل)، جاستروتكس (ميتالديهيد) بالإضافة إلى المبيد الحيوي بيوجارد (بكتيريا بى تى) بالمعدلات الحقلية الموصى بها لمكافحة القوقع البنى تحت الظروف الحقلية في بستان جوافة بمحافظة الإسكندرية. أظهرت النتائج المتحصل عليها أن جميع المركبات المختبرة أدت إلى انخفاض معنوي في عدد القواقع الحية على أشجار الجوافة بعد يوم واحد من المعاملة وحتى نهاية التجربة مقارنة بالأشجار غير المعاملة. وبحساب نسب الخفض، تبين أن المبيدات الثلاثة التي تم اختبارها كانت سامة للقوقع البنى بدرجات متفاوتة؛ 79,39، 69,12، 86,57% للميثوميل، بكتيريا بى تى، والميتالديهيد بعد 21 يوم من التجربة، على التوالي. كما أن متوسط القتل الأولي (%) كان 28,67، 16,39 و41,66 ومتوسط التأثير المتبقي (%) كان 67,98، 59,55 و78,81 للميثوميل، بكتيريا بى تى، والميتالديهيد، على التوالي. وبمقارنة المبيدات التي تم اختبارها ببعضها، أحتل الميتالديهيد المركز الأول وأظهر أعلى فعالية ضد القوقع البنى الذي يصيب الجوافة، يليه للميثوميل ثم بكتيريا بى تى.